#6
Amendment B
172A 3054 J. Whb
1-22-02

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of:

HIROKAZU IWATA

Serial No.: 09/746,600

Filed: December 21, 2000

For: HIGH FREQUENCY PIEZOELECTRIC RESONATOR HAVING REDUCED SPURIOUS MODES (As Amended)

Art Unit: 2834

Examiner: J. Gonzalez

AMENDMENT

Assistant Commissioner for Patents
Washington, D.C. 20231

Dear Sir:

In response to the Office Action dated June 21, 2001, please amend the above-identified application as follows:

IN THE SPECIFICATION:

Please replace the paragraph extending from page 11, line 16 through page 12, line 2 with the following rewritten paragraph:

B1

--Figs. 1(a) and 1(b) are views illustrating the construction of an AT cut high frequency crystal resonator according to the invention, and Fig. 1(a) being a plan view thereof and Fig. 1(b) being a sectional view taken along a line Q-Q. On a flat-surface side of a crystal plate 1 the other surface of that has formed therein a recess, there is disposed a main electrode (an excitation electrode) 2. From the electrode 2 there is extended toward an edge of the crystal plate 1 a lead electrode 3. Further, a second electrode 5 is so provided as to surround the peripheral edge of the main electrode 2 with a gap 4 in between. The size of the electrode 5 is made substantially the same as that of the recess 6 formed in the crystal plate 1. And, on a recess side there is formed an entire electrode (an excitation electrode) 7.--

Please replace the last paragraph bridging pages 13 and 14 with the following rewritten paragraph:

B2 --Setting the center of the main electrode 2 to be the origin (0) and the dimensions of the respective electrode portions to be as stated previously as illustrated in Fig. 1(b) and assuming that the crystal plate 1 be an isotropic elastic body, one dimensional analyses of the thickness shear mode were performed. In the Japanese Patent Application Laid-Open No. Hei-9-27729 that is previously cited, analysis is made using the frequency equation that has been established under the assumption that the edge of the substrate be a free edge. However, in the case of a resonator wherein the periphery of the vibration portion is retained by the annular surrounding portion as in the invention, the frequency equation should be established under the assumption that the edge of the vibration portion be a fixed edge. Accordingly, the frequency equation is as follows.--

Please replace the last paragraph on page 18 with the following rewritten paragraph:

B3 --Fig. 5 is a plan view illustrating the main electrode and second electrode constituting a main part of the piezoelectric resonator according to a third embodiment of the present invention. The difference of Fig. 5 from Fig. 1 is that an elliptic main electrode (an excitation electrode) 2a is disposed as the main electrode (excitation electrode) 2 illustrated in Fig. 1(a). This difference further resides in that an elliptic groove hole is formed in the central part of the plate so as to surround the peripheral edge of the main electrode 2a with a gap. That difference further resides in that a second electrode 5a substantially corresponding to the recess 6 of the crystal plate 1 is disposed around the main electrode 2a with the elliptic groove hole in between. That an entire electrode is disposed over the recess of the crystal plate is the same as in Fig. 1.--

Please replace the first full paragraph on page 19 with the following rewritten paragraph:

B4 --The reason for having made the main electrode 2a elliptic is as follows. Determining the two-dimensional vibration displacement distribution of the main vibration, as an attempt, by applying a finite element method, it is seen that the displacement distribution of the main vibration is elliptical due to the anisotropy of the crystallographic axis of the crystal plate. Therefore, manufacturing a high frequency resonator wherein the main electrode is formed elliptic in conformity with the displacement distribution of the main vibration and the second

B4 electrode is formed with an elliptical hole that surrounds the main electrode with a gap formed in between, the production of spurious is suppressed. Resultantly, a resonator whose capacitance ratio is minimal is obtained.--

Please replace the first full paragraph on page 20 with the following rewritten paragraph:

B5 --The characterizing feature of the fourth embodiment is as follows. After forming the convex portion T on the crystal plate 1 beforehand, the main electrode 2b is formed on the convex portion T. Therefore, even when making the main electrode 2b, lead electrode 3b, and second electrode 5b the same in material quality and in film thickness, the respective cutoff frequencies thereof have the relationship of $f1 < f3 < f2$. Resultantly, it has become possible to satisfactorily achieve the relevant edge by performing the evaporating or sputtering and photolithography, respectively, only once.--

IN THE TITLE:

Please delete the title and substitute therefor:

B6 --HIGH FREQUENCY PIEZOELECTRIC RESONATOR HAVING REDUCED SPURIOUS MODES--.

IN THE CLAIMS:

Claim 2 has been amended as follows:

B7 2. (Amended) A high frequency piezoelectric resonator according to claim 1, wherein the density of the material of the second electrode is made lower than that of the main electrode; and dimensional values of the main electrode, second electrode, and gap are set so that an anti-symmetric 0th mode does not become a trapped mode.

REMARKS

Applicant has amended the specification, title, drawings and claim 2. Applicant respectfully submits that these amendments to the claims are supported by the application as originally filed and do not contain any new matter. Accordingly, the Office Action will be discussed in terms of the specification, title, drawings and claims as amended.

The Examiner has objected to the disclosure stating that it is unclear the meaning of the letter "a" in page 14, line 15. In reply thereto, the letter "a" is the same "a" that appears in Equation 6 on page 14.

Next, the Examiner states that title is misdescriptive and requests a new title. Applicant has amended the title and respectfully submits that the new title is more descriptive of the invention to which the claims are directed.

The Examiner requests that Figs. 7a, 7b and 8-11 be designated as "Prior Art". By the enclosed letter to the Chief Draftsperson submitted for the Examiner's approval, Applicant has designated Figs. 7a, 7b and 8-11 as prior art.

The Examiner has objected to the drawings stating that the reference character 1 has been used to designate both substrate and crystal plate and because in page 19, line 9, it discloses that both electrodes are elliptical while the drawing in Fig. 5 only showed that the main electrode is elliptical. In reply thereto, Applicant has amended the specification to clearly indicate that the reference character 1 only relates to the crystal plate and has also amended page 19 to indicate that only the main electrode is elliptical. Accordingly, Applicant respectfully requests that the Examiner withdraw his objection to the drawings.

The Examiner has rejected claim 2 under 35 USC 112, second paragraph, as being indefinite. Applicant has amended claim 2 to make it more definite. In addition, Applicant would like to further point out that the values mentioned in claim 2 are in fact the dimensional values of the main and second electrodes and the gap between the main electrode and the second electrode. By selecting these dimensional values, the operational modes of the piezoelectric resonator are set. One such mode is a trapped mode and that is the situation in which the energy of the vibration mode excited on the piezoelectric plate is trapped on the main electrode. Still further, the anti-symmetric 0^{th} mode is one of the anti-symmetric modes of a piezoelectric resonator and as such it is one of the inharmonic modes which causes spurious vibrations. Accordingly, it is desirable that the vibration energy not be trapped on the main electrode in the anti-symmetric 0^{th} mode.

In view of the above, therefore, Applicant respectfully submits that claim 2 now complies with 35 USC 112, second paragraph.

The Examiner has rejected claims 1-12 under 35 USC 103 as being obvious over Eda et al. in view of Novikov, stating that Eda et al. discloses a high frequency piezoelectric resonator

including a plate having main electrodes 26, a pair of secondary electrodes 16, a recess in the piezoelectric plate (see Fig. 26A) and a main electrode having an elliptic shape (see Fig. 26B), and a second electrode divided into a plurality of portions (see abstract), but does not disclose that the electrodes are made of different materials; Novikov discloses that for the purpose of improving the accuracy of measurement of amplitude over a wide range of frequency spectrum that the electrodes are made of different materials and have different densities (see abstract); and it would have been obvious to one of ordinary skill in the art to modify Eda et al. to include the different materials for the electrodes as suggested by Novikov.

In response thereto, Applicant would like to first point out that Applicant's invention was developed or created to overcome two problems of the prior art for high frequency piezoelectric resonators. One problem is that when setting the electrode film thickness of the main and second electrodes, the energy of the anti-symmetric mode is set in order to suppress spurious modes, to be an energy trapping coefficient that is immediately before being trapped. In this case, for a 150 MHz range piezoelectric resonator having a recess therein, it is necessary to form the electrode film thickness with a precision of 10% or less so as to make the difference in thickness of the main and second electrodes. This, however, is beyond current film forming capability. Another problem is that due to the unevenness of the flatness and the lack of parallelism of etching the substrate that is as thin as 10 μm in its vibration area, the electrical charge of the anti-symmetric mode cannot be offset and the anti-symmetric mode appears as very strong spurious signals. Thus, the energy trapping coefficient needs to be very small so as to avoid the energy of the anti-symmetric mode from being trapped.

More specifically, so as to obtain precise film thickness differences between the first electrode and the second electrode, in Applicant's invention, different materials are used for the main and second electrodes. For instance, gold and silver which differ in electrode density are employed in the present invention. Also, the electrode film thickness and groove depth between the main and second electrodes are set so that the anti-symmetric mode does not become a trapped mode.

Furthermore, in another embodiment, by way of shaping the main electrode in an elliptic shape, the spurious mode is suppressed, and the capacitance ratio becomes minimum. Also, in Applicant's invention, a convex portion is formed on the main surface that is on the flat side, and the main electrode is formed on the convex portion. Thus, even in a case when the material and

the film thickness of the main and second electrodes are both the same, the relationship of the cut-off frequencies f1, f2 and f3 shown in Fig. 6 in Applicant's application assume the desired relationship of f1<f3<f2. As a result, only the symmetric mode becomes the trapped mode. Thus, within a controllable range of an ordinary evaporating or sputtering apparatus, it becomes possible to form the desired electrode film thickness with sufficient precision. Furthermore, in Applicant's invention, the second electrode is divided into a plurality of portions and with this structure, even when unevenness in thickness occurs in each of the electrodes, the spurious signals caused by anti-symmetric mode can be suppressed by way of fine frequency adjustment in the divided portions of the second electrode.

With the above in mind, Applicant has carefully reviewed the art relied upon by the Examiner. In particular, Applicant has carefully reviewed Eda et al. and respectfully submits that Eda et al. indicates that Fig. 26A shows that the quartz oscillator 22 is mounted on a substrate and a part of the substrate on which the lower excitation electrode 27 faces the main electrode 26 of the quartz oscillator 22 is removed by etching to form a recess. Still further, Applicant respectfully submits that in Fig. 26B, the exciting electrode 26 of the quartz oscillator 22 is an electrical shape. However, as seen from Figs. 22 and 23, it is not shown that the pair of second electrode 16 surround the main electrode and Applicant respectfully submits that the other figures do not show this as well. Applicant's further review indicates that Figs. 22 and 23 and Examples 27 and 28 indicate that a pair of second electrodes are formed only on one of the main surfaces of the crystal substrate 12 which is mounted on the substrate 11. In other words, the pair of second electrodes are surface acoustic resonators (SAW) that are comprised of a pair of comb-like electrodes. It is this pair of second electrodes acting as surface acoustic resonators which the Examiner has identified as a "second electrode divided into a plurality of portions." However, Applicant respectfully submits that as seen from Fig. 37, by dividing the electrode a piezoelectric filter is provided that is comprised of the divided electrodes and the facing electrodes that is provided on the main surface of the recess formed inside. Accordingly, Applicant respectfully submits that the main electrode 26 of Eda et al. is merely an exciting electrode of the prior art piezoelectric resonators and the recess is a means for realizing a prior art 150 MHz high frequency piezoelectric resonator.

In contrast thereto, in Applicant's invention, the excitation electrode that is formed on a flat piezoelectric substrate on a piezoelectric plate having a recess is used as a main electrode and

a second electrode is provided so as to surround the main electrode with a predetermined gap in between and further the dimensions of the electrodes and the gaps are set so that an anti-symmetric mode does not become the trapped mode.

Applicant has further carefully reviewed Novikov and respectfully submits that in the abstract thereof, it merely discloses that the exciting electrodes 3 and 4 are made of different materials of different densities and there is no showing of the structure of the piezoelectric resonator. Still further, Applicant respectfully submits that Novikov does not disclose why the exciting electrodes of the piezoelectric resonator are made of different materials so as to increase the detection precision of the frequency. Finally, Applicant respectfully submits that Novikov does not show or suggest that the main and second electrodes would be made from different materials.

In view of the above, therefore, Applicant respectfully submits that the combination of Eda et al. and Novikov is not Applicant's invention. Therefore, Applicant respectfully submits that claims 1-12 are not obvious over Eda et al. in view of Novikov.

Applicant further respectfully and retroactively requests a one month extension of time so as to respond to the Office Action and enclosed herewith is a check in the sum of $110.00 as the fee.

Attached hereto is a marked-up version of the changes made to the specification, title, drawings and claims by the current amendment. The attached page is captioned "Version with markings to show changes made."

In view of the above, therefore, it is respectfully requested that this Amendment be entered, favorably considered and the case passed to issue.

Please charge any additional costs incurred by or in order to implement this Amendment or required by any requests for extensions of time to KODA & ANDROLIA DEPOSIT ACCOUNT NO. 11-1445.

Respectfully submitted,

KODA & ANDROLIA

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